DRAFT TRANSLATION

NASA TT F-8233

JUN 4 1962

SPECTROMETER FOR MEASUREMENT OF SOLAR EMISSION IN THE EXTREME ULTRAVIOLET

(Spektrometr dlya izmereniya izlucheniya solntsa v dalekom ul'traviolete)

Sb."ISZ", (AES),
vyp.11, pp. 23-29,
Izd-vo A.N.SSSR, 1961.

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In order to conduct extra-atmospheric research in the solar far ultraviolet, we conceived a two-channel diffraction spectrometer. The following considerations and requirements were taken into account during the planning stage of its construction.

1. The absence of any materials that are transparent for most of the far ultraviolet renders impossible the use of filters, and compels one to utilize for the spectral decomposition a concave grating. For the same reason, open-type secondary-electron VEU-multipliers must be used as photoreceivers.

2. It is necessary to condut the measurements by way of comparison with some standard (in the energetic sense) radiation. It has been found most appropriate to use for that purpose the well known, time-constant continuous solar emission in the 1700 — 2000 Å wavelength range.

3. In order to isolate the investigated emission line against the background, the spectrum scanning procedure may be utilized over a

a small portion near that line.

4. The illumination by solar emission of the instrument's inlet slit is achieved with the aid of a tracking system. Because of the required high consumption of energy, it is deemed appropriate to refrain from bringing-on the whole spectrometer and to track the Sun by means of a fused-quartz-made light mirror covered with a thin thorium dioxide film. This allows a reduction of the necessary feeding resour , but results at the same time in a certain additional loss of light.

5. The electron-registering part of the instrument must be operative for strong as well as very weak luminous fluxes. This requirement stems from the following considerations: The intensities of the measured lines are known only very approximately and their magnitudes may oscillate within rather broad limits. Thus, for instance, data from various authors on the line λ 303.8 Å intensity [1 — 4] vary almost tenfold, while for the measurement of its magnitude with a precision to 10 percent, the system must be able to measure luminous fluxes in a range of up to three orders. Besides, the variation of the tracking mirror's reflection factor with that of the tracking angle, and the rather low precision in the determination of the efficiency of instrument's optical components in the investigated spectral region may lead to a tenfold difference between the luminous flux actually reaching the photoreceiver and the precalculated one. Nor excluded is the possibility of sensitivity variations of both, the electron circuit and the photoreceiver itself. All this leads to the necessity of creating a registering circuit capable of conducting measurements in range greater or equal to 10^5 for a maximum value of

10 erg $\cdot$ cm^{-2}$\cdot$sec^{-1} for the flux. of all emission lines. Finally, one must bear in mind the necessity of investigating the temporal variation of the emission that may lead, for example in case of solar flares, to flux' oscillations of the order of 10 to 100 times.

SPECTROMETER

The worked out variant of the instrument is designed for measurement of Sun's ultraviolet resonance line of ionized helium — HeII λ 303.8. However, an insignificant modification of the instrument's optical part may extend its application to the study of emissions of other lines, such as HeII λ 584, L_α for example. As to the electron-registering circuit, no changes are then required.

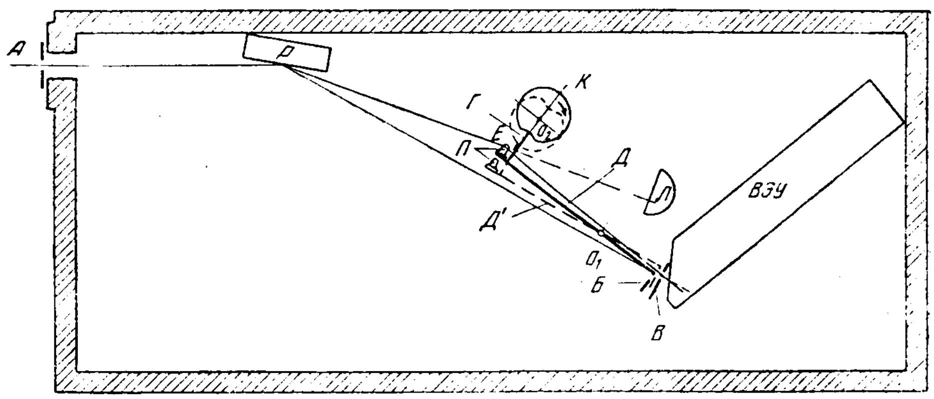

Fig. 1. Block-diagram of Spectrometer's kinematic scheme.

A - inlet slit; Б — scanning slit; В - exit diaphragm; Р — diffraction grating; K — cam; Д — yoke; Г — finger; Л — trap ; E — focus of the zero-order spectrum; П — quartz prism.

The thus-planned and built two-channel diffraction spectrometer allows the reception at the cathode of the photomultiplier of emissions from the 1700 — 2000 Å region (spectrum of the zero order used for calibration), and then to effect the scanning near the line λ 303.8 Å of a certain portion of the spectrum of the second order.

The dispersive element is a replica of the concave diffraction grating, having 1200 lines per 1 mm, a 500 mm curvature radius, and an 80° operating angle of incidence. The inlet slit has 0.2 by 7 mm^2 dimensions. The grating's reverse linear dispersion in the direction perpendicular to the diaphragmed ray, constitutes 16 Å mm^{-1}.

The radiation receiver is a secondary-electron open-type VEU— multiplier with a photocathode and diodes made of oxidized beryllium bronze 5, 6 . The use of such multipliers, very little sensitive to long wave radiation, permitted to reduce significantly the effect of scattered light in the spectrometer on the results of measurements.

The optical and kinematic circuit is represented in Fig.1. (see also the captions). Let us add that the exit diaphragm has 2 x 20 mm. dimensions. On the yoke Д swinging around the axis O_1 there is at one end a quartz prism П with a 30° refraction angle, and at the other — the scanning slit Б of 0.1 by 0.15 mm. dimensions; behind the exit diaphragm B there is located the FEU— photocathode. The swinging of the yoke is effected by an impulse-cycle motor, rotating the cam K with a double cardioid upon which rests the yoke's finger. At cam's rotation the yoke may occupy any position between the two extremes — Д and Д' . In the position Д the quartz prism П catches the zero order rays and directs them (with a small spectral decomposition) to the exit diaphragm B, so that a position of the spectrum between 1700 and

2000 Å passes through that diaphragm's cut, and reaches the VEU- photocathode. In this way the measurement of the calibration signal is assured.

At cam's displacement from the extreme position, the finger comes out of the region of dual cardioid's minimum and the prism П shifts in such a way that the zero order rays can now freely pass into the trap Л. At further cardioid rotation the yoke gradually shifts, reaching the second borderline position Д'. At the same time, the scanning slit Б passes in front of the exit diaphragm B, scanning a portion of the spectrum 30 Å wide near the line λ 303.8 A.

The position of the line HeII λ 303.8 relative to the diaphragm B was determined in advance by photographing the discharge tube spectrum with the flowing helium. To that effect the whole instrument was placed in a vacuum chamber, and a chassis with a film, sensitized by oil, was disposed behind the diaphragm B.

In the extreme position Д' the yoke closes the contact, while voltage is switched off at the same time in the measurement-registering circuit, and the system emits the control zero signal ("zero beating off") At further rotation of the cam the yoke leaves the contact, the scanning slit begins to scan the spectrum in the reverse order. Finally, the prism П hits the zero order spectrum region, the registration of the calibration signal begins, and the cycle begins repeating itself.

The total duration of the cycle is 170 sec. About 7 to 8 sec correspond to zero order registration, and about 4 to 5 — to the control zero signal ("Zero beating off"). The latter is introduced into the scheme merely as a control of scanning installation operation and for separating one cycle from another. The scanning slit's shifting for a second represents 0.05 mm.

The spectrometer containing part of the electronic circuit is assembled in a rectangular duralumin box, whose contours are shown in Fig.1. Four bolts are used at the front wall to reinforce the tracking system [7]. To facilitate the instrument's evacuation at entering the orbit and during the flight over its first portions, apertures of about 2 cm^2, screened by light labyrinths, are made in the lateral walls of the box. To protect the VEU from discharges between dinodes at poor vacuum, the switching on of the instruments 20 minutes after entering orbit was foreseen.

The whole instrument consists of four parts: 1) the spectrometer-proper with a reinforced tracking system in it; 2) the tracking system's electric control block (ECB); 3) the measurement-registering system's electric block (ERB); 4) the feeding block — chemical elements' battery.

The spectrometer with the tracking system is shown in Fig.2. This part of the instrument is adjusted on the exterior surface of the spaceship-satellite by means of six bolts. The remaining parts are located inside the instrument container.

Measurement-Registering Installation

The block-diagram of such an installation is shown in Fig.3, while the principle of the circuit is presented in Fig.4. Part of the components of the measurement-registering installation, and namely: block 16 — VEU; 17 — generator feeding VEU; 18 — voltage multiplier, and 19 — the preliminary amplifier, all are inside the spectrometer's frame. Blocks 1 through 12 are in ERB.

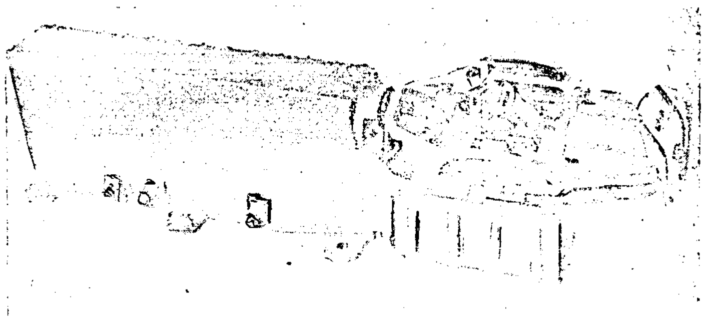

Fig.2.- Exterior view of the Spectrometer.

The switching on of the whole instrument is made by an installation including a relay acting on command at the 20th minute after entering orbit. After that start the tracking system (TS) and the scanning installation 13, controlled by the impulse-cycle generator 11. This generator is assembled in a circuit on triodes П48 and П49 of a dissymmetric multivibrator. The pulse duration was 0.2 to 0.3 seconds. The pulses were reinforced by the П50 triode, and fed to the spectrometer, where they set in motion the scanning device 13. For the VEU high-voltage feeding there is a special block located inside the spectrometer's box. It is a two-cycle generator assembled on triodes П51 and П52, and a rectifier with a sixteen-cascade voltage multiplication.

From VEU signals are picked up in the form of pulses of current, whose frequency is proportional to photocathode illumination. These

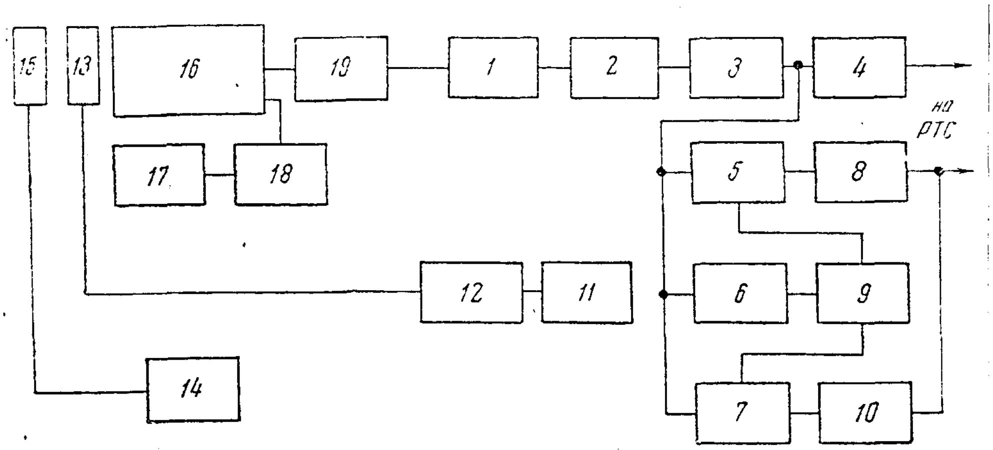

Fig.3.- Block-diagram of the Instrument.

1 — amplifier; 2 — trigger compartment; 3 — amplifier with an emitting repeater; 4 — counting rate measuring device witha logarithmic scale; 5 — channel's key circuit with f < 2.5 kc/s; 6 — Analyzer's counting rate measurer; 7 — channel's key circuit with f < 25 kc/s; 8— channel's counting rate measuerr with f < 2.5 kc/s; 9 — analyzer with a command installation ; 10 — Channel's counting rate measurer with f < 25 kc/c; 11 — cycle-pulse generator; 12 — amplifier; 13 — scanning device; 14 — tracking system control block; 15 — tracking head; 16 — VЭU ; 17 — Generator; 18 — voltage multiplier; 19 — preliminary amplifier.

These signals are fed to the preliminary amplifier 19, consisting of semiconductor triodes П69 — П73 and located in the spectrometer's box. From its output pulses are fed to the ERB block along a coaxial cable. There they enter the input of the basic amplifier 1, assembled on transistors П1— П 8. At its output pulses set on the trigger compartment 2, transforming them into rectangular and lowering twice their frequency. The rectangular pulses are amplified by the amplifier 3. The trigger compartment 2 is assembled on triodes П 11 and П 12; the rectangular pulse amplifier is assembled on transistors П13 and П14. From amplifier's 3 output rectangular pulses enter the input of nodes 4, 5, 6 and 7 at once, these being assembled on triodes П25, П43, П23 and П45. In the node 4, a transformation takes place of rectangular pulses into a direct-current voltage proportional to the

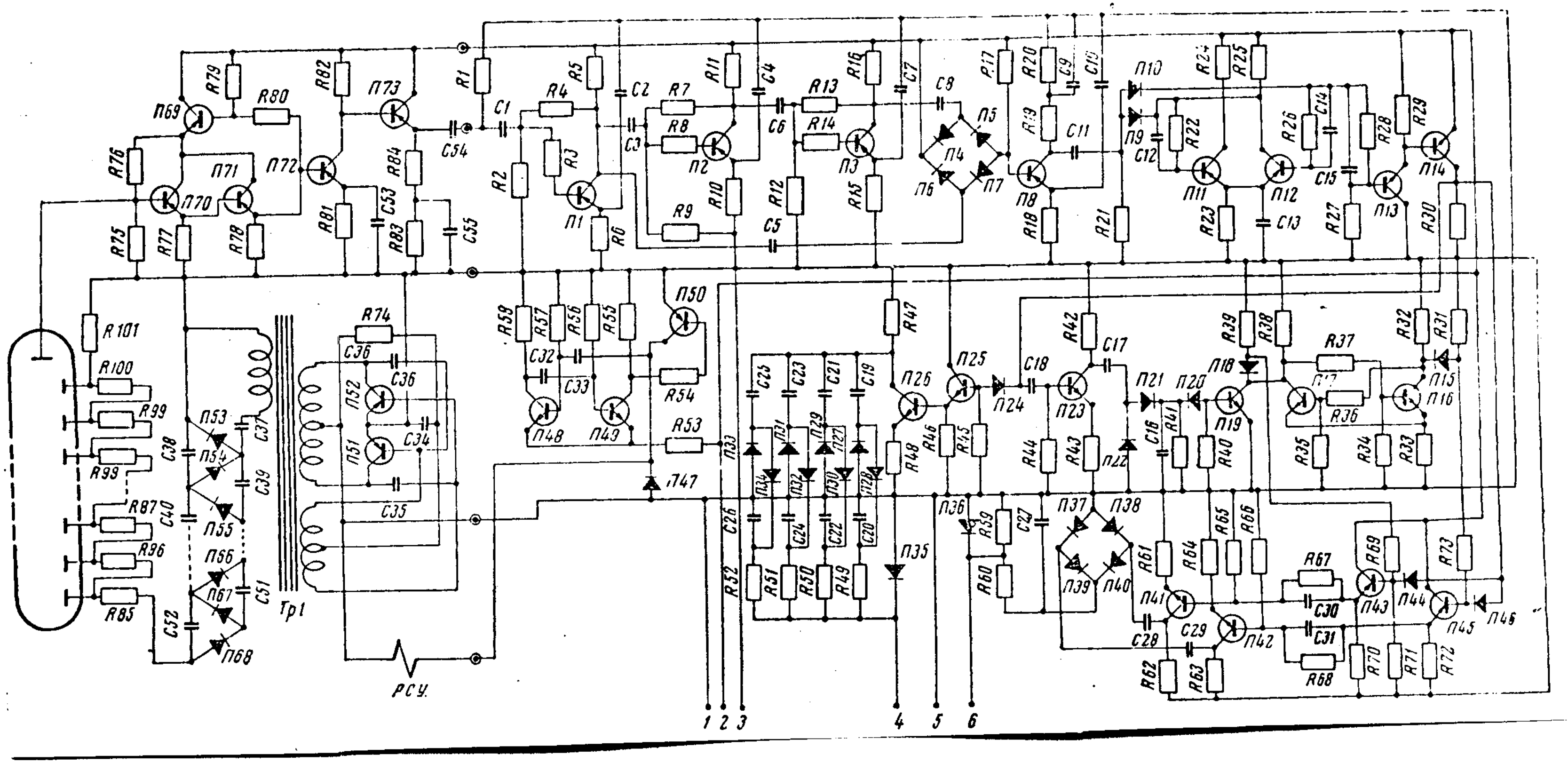

Fig.4.- Schematic Measurement System Circuit:

P.C.Y.- scanning device's relay; 1,2,3 — contact to the feeding source ; 4 — ИСС output in the logarithmic scale; 5 — PTC General lead; 6— ИСС output with linear scale.

to the logarithm of their mean tracking frequency. The time constant of that scale's output is about equal to 1 second.

The nodes 5 and 7 constitute key circuits which are controlled by the command installation 9. At low pulse tracking freqeuency, key 5 is open, which lets the signal pass to counting rate measurer (ИСС) 8-operating within the first measurement limit As the pulse frequency increases, open is key 5, which lets the signal through to the counting rate mesurer (ИСС) 8, operating in the first measurement range. At pulse frequency increase, the outpu voltage also increases in frequency close to to 2.5 kc/s , and reaches 6 volt.

At further freouency increase, a circuit change-over to another measurement range takes place, the command (control) installation 9 locks the key 5 and opens the key 7, which lets the signal through to the counting rate measurer 10, operating in the 2.5 — 25 kc/s range. The output voltage drops then tenfold in a jump-like fashion, and then increases lineraly at frequency increase of input pulses, so as to reach 6 volts at 25 kc/s frequency.

At smooth pulse frequency decrease from 25 kc/s the whole process takes place in the reverse order: as the frecuency decreases from 25 to 2.5 kc/s, the output voltage decreases. In the 2.5 kc.s frequency region a change-over takes place toward the first measurement range, the voltage increases to 6 v., and then, at further frequency decrease it drops proportionally to the freouency. Element 9 is assembled on triodes П16, П17 and П19; elements 8 — 10 —- on triodes П41 and П42 respectively.

To protect the telemetry from random overvoltages in output, bounded stabilitrons П35 and П36 stand in the output circuits.

The electron-registring circuit operates in such a fashion that it simultaneously delivers measurements in two forms: first — from the block 4 in the whole pulse tracking frequency variation range, from 1 to 10 c/s in the logarithmic scale; the second — from blocks 8 or 10 in linear scale.

With view of checking the operation of the measurement-registering apparatus, a signal was fed to telemetry, determining the amplifier's feed voltage.

The above-described instrument was installed in the third spaceship-satellite. The results obtained in the course of this experiment are described in [8] (NASA TT F-8232).

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Entered on June 10, 1961.

Translated by ANDRE L. BRICHANT

for the

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

June First, 1962.

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